PREPARATION FOR OPERATIONS FR-2 -- E O L E

NOTE no. 4

OBJECT: OPERATION PRINCIPLE OF THE U H F EQUIPMENT SHIPPED

Centre National d'Etudes Spatiales
Centre Spatial de Bretigny

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NATIONAL SPACE STUDIES CENTER

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Preparation for Operations

FR-2 - EOLE

Note no. 4

Object: Operation principle of the UHF equipment shipped

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I - INTRODUCTION

Note no. 1 "Preparation for EOLE operations" (ref. 25/COBY of 2/24/69) described the principle characteristics of the UHF satellite/balloon/satellite connection. This new note completes the preceding one while taking into account the operation of the equipment shipped on board the balloons and the satellite.

II - GENERALITIES ON THE BALLOON

The balloons of the EOLE project will evolve around the 200 mB isobar or about 11,000 m. This altitude imposes constraints linked to aerial security and to the particularly severe climatic conditions (temperature on the order of $-60^{\circ}C$, leaking and icing in the course of the ascension).

The configuration of the nacelle, its operation, and the materials utilized are particularly important when taking into account these constraints.

II - 1 COVERINGS

The coverings should be air tight and inextensible in order that the balloon can remain at a constant ceiling. Of a diameter of 4 m, they are made up of shortened spindles in a plastic and resistant material, assembled by a special adhesive. They are filled with helium.

II - 2 NACELLES

The nacelles are made up of several elements:

- the electronic equipment which is present essentially as an answering device associated with a coding and decoding system.

- the antenna whose radiation diagram ought to be the most isotropic possible in outer space, while assuring proper protection for the rays affected by the terrestrial surface.

- the power system composed of a solar generator and a battery.
- the captors and the destruction system.

III - OPERATION PRINCIPLE OF THE NACELLE

Given the power system problems caused by the thermic constraint and taking into account the fact that the satellite is not constantly visible from the balloon, the general operation of the nacelle is the following:

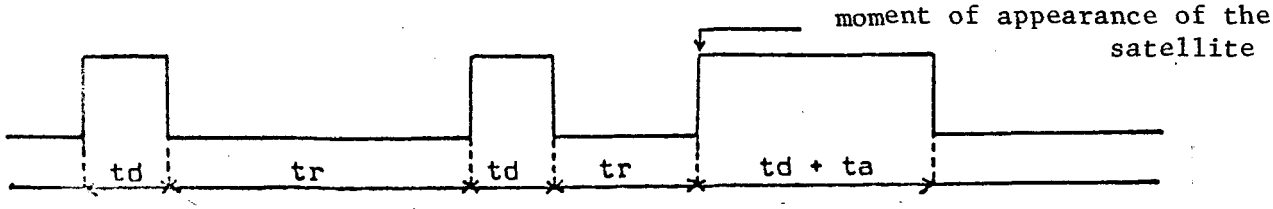
III-1 - STAND-BY PULSE, DETECTION

At regular intervals, one second every twenty seconds, a timer connected to a power supply system delivers a signal which permits putting the receiver on power, the other equipment is not powered, and permits expecting the UHF signal transmitted by the satellite.

III-2 - ACQUISITION

When the receiver detects the UHF signal, it attempts to lock itself in phase by means of a "VCXO," on the transmission of the satellite, the power supply of the receiver being permanent.

Acquisition time, defined as the time separating the moment of satellite appearance from the moment of end of acquisition is at the maximum 30 seconds, whatever the moment of appearance of the satellite in the cycle imposed by the timer may be.



td = detection time 1 second
tr = rest time 20 seconds
td + ta = acquisition time 30 seconds maximum

III-3 RECEPTION

When the acquisition is obtained, the receiver delivers:

a) A signal to power the equipment treating the call messages;

b) A signal issued from an amplitude demodulator;

c) A signal issued from a phase demodulator.

III-4 TREATMENT

A - A loop is controlled in phase on the signal issued from the amplitude demodulator.

This system reconstitutes the bit cadence thus creating a balloon timer at 48 Hz.

B - Two filters centered on the F0 and F1 frequency (modulation frequencies of the "0" bits and of the "1" bits) receive the signals issued from the phase demodulator.

The signals thus filtered are applied to a commutator in sight of their return to the satellite in order to permit distance measure and to permit a system which reconstitutes the train of bits received.

The latter is applied to a decoder/commutator assembly whose role is:

a) to look for a "beginning of message" word made up of six "0" bits, six "1" bits or six "1" bits, 6 "0" bits serving as a synchronization word.

b) making certain that the received bits are correct.

The particular make up of the 18 PN bits permits this test. Indeed, the 10th bit received of the 18 PN bits is produced by addition module 2 of the 1st and 5th bits received.

c) comparing the address of the balloon called to the address posted on board the nacelle.

d) decoding the order to be executed if there is recognition of the address (operation or destruction) and furnishing a signal to put the transmitter on power.

e) executing the order:

The response sequence is elaborated by the commutator.

After transmission of a pure bearing, the transmitter is modulated by the signal delivered by the commutator:

6 "0" bits available at the output of the Fo filter

6 "1" bits available at the output of the F1 filter

4 signals issued from the captors.

After transmission of this sequence, the transmitter is no longer powered. When the satellite is no longer visible, the receiver detects the loss of it, the nacelle functions in "stand-by pulse - detection."

The general operation of the nacelle is presented in the diagram on page 6.

The synoptic schema of the nacelle is presented on page 7.

III-5 PARTICULAR CASE FOR THE DESTRUCTION ORDER

In the case where a destruction order is given in a call message, the destruction system of the covering is activated after transmission of the first two informations issued from the captors.

By the order of the nacelle operation, a message containing a destruction order involves, for the balloon previously called, the impossibility of retransmitting the distance information since the commutator successively collects the signals available at the output of the F0 and F1 filters when the nacelle receives "1" and "0" bits instead of "0" and "1" bits (this case is only presented in the non sequential call).

This fact is made obvious in the diagram of times presented on page 8.

Ballon b1 cannot retransmit any distance information since it receives the 6 "1" - 6 "0" corresponding to the destruction order contained in the call message of balloon b2.

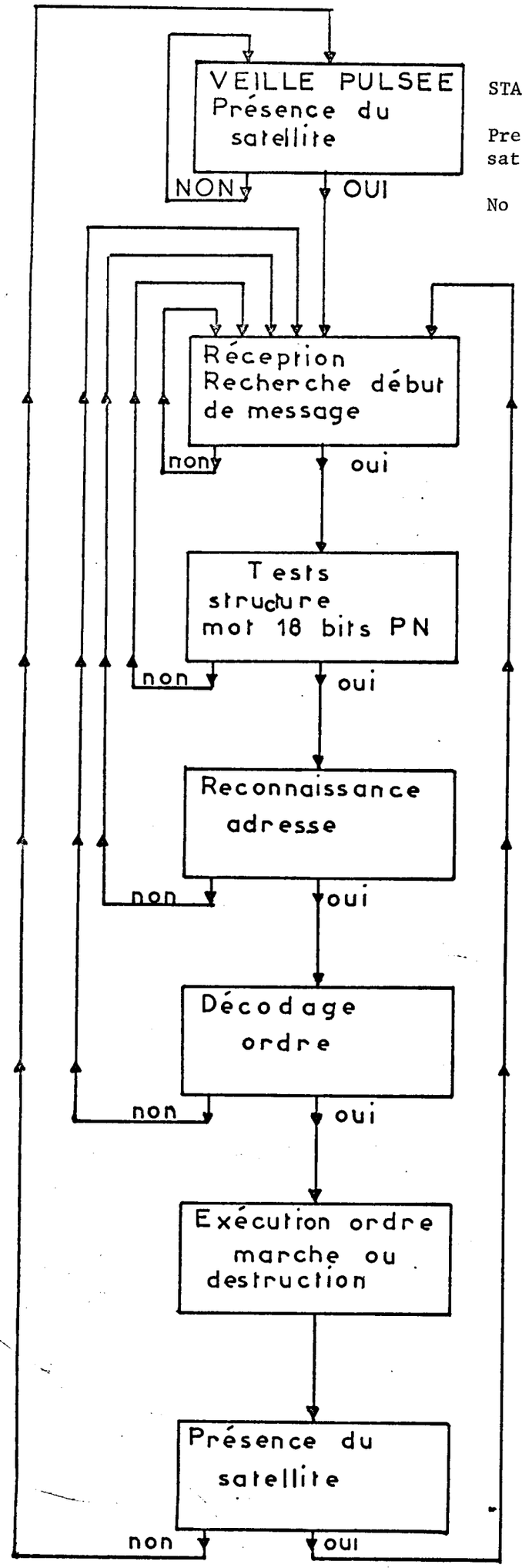
IV - CONFIGURATION OF THE NACELLE (cf. page 9)

The existence of equipped balloons drifting at cruising altitudes of intercontinental airplanes should not create a danger for aerial navigation.

Since specifications concerning the mass, the volume, the form of the miscellaneous components, the nature of the materials and the topology of assembly have been defined following studies of nacelle impact on a glass casing in order to minimize the effects of an eventual balloon-airplane collision.

Beginning with the balloon, in which are included the destruction apparatus and the excess pressure captor, are suspended:

- the pressure and temperature captors,
- the solar generator,
- the battery,
- the electronic,
- the antenna.



STAND BY PULSE

Presence of the satellite

No Yes

Reception
Expectation of the beginning of the message

No Yes

Tests
Structure
Word 18 PN bits

No Yes

Recognition

Address

No Yes

Decoding order

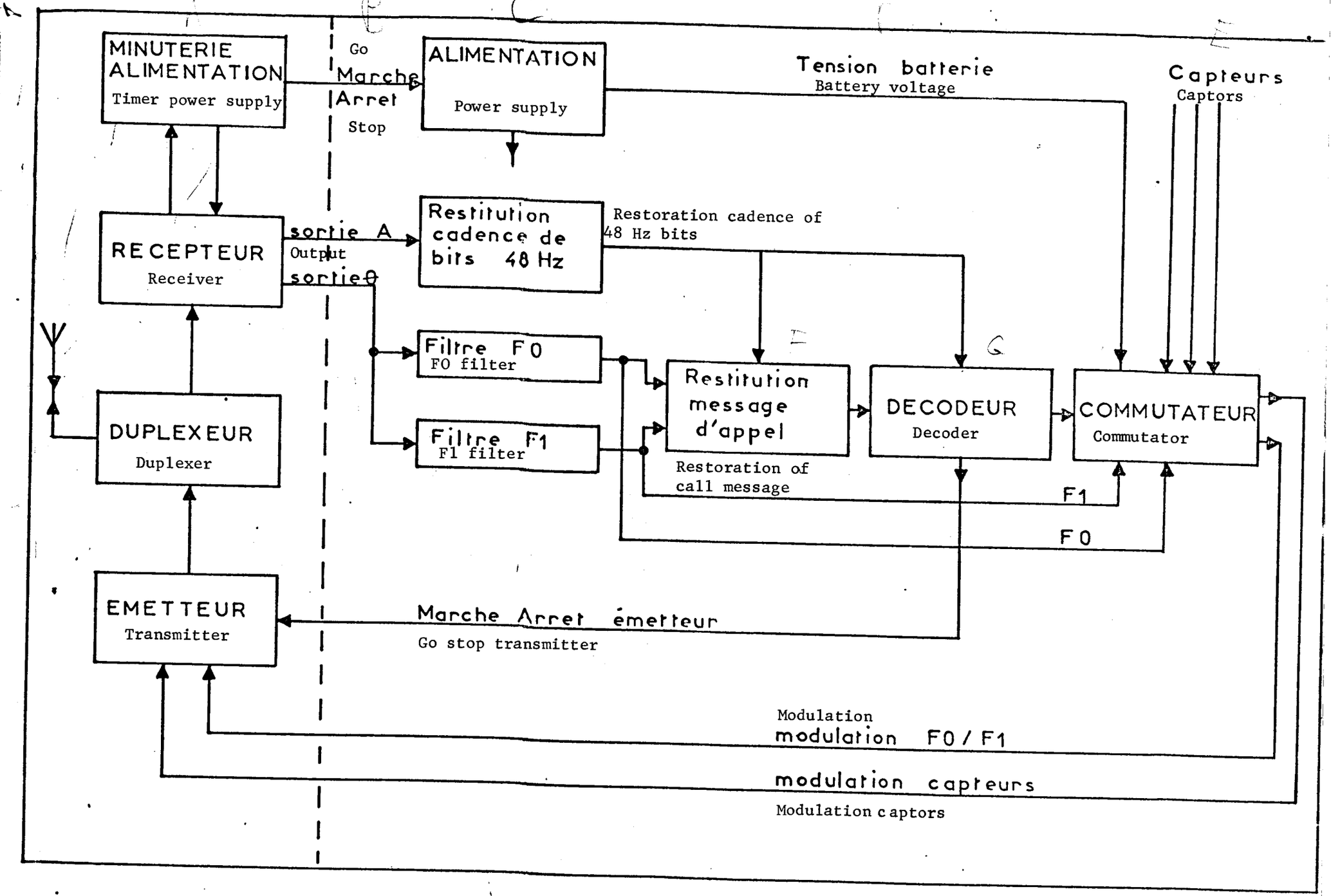
No Yes

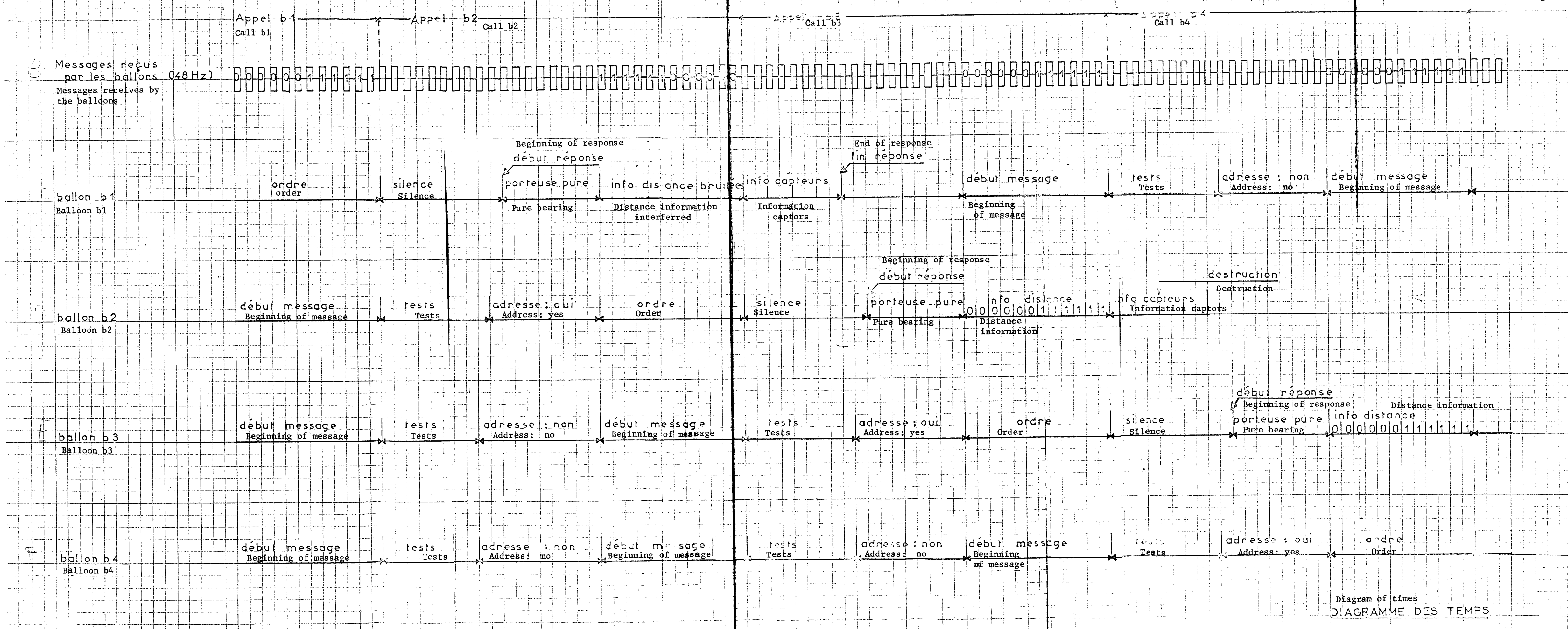
Order execution

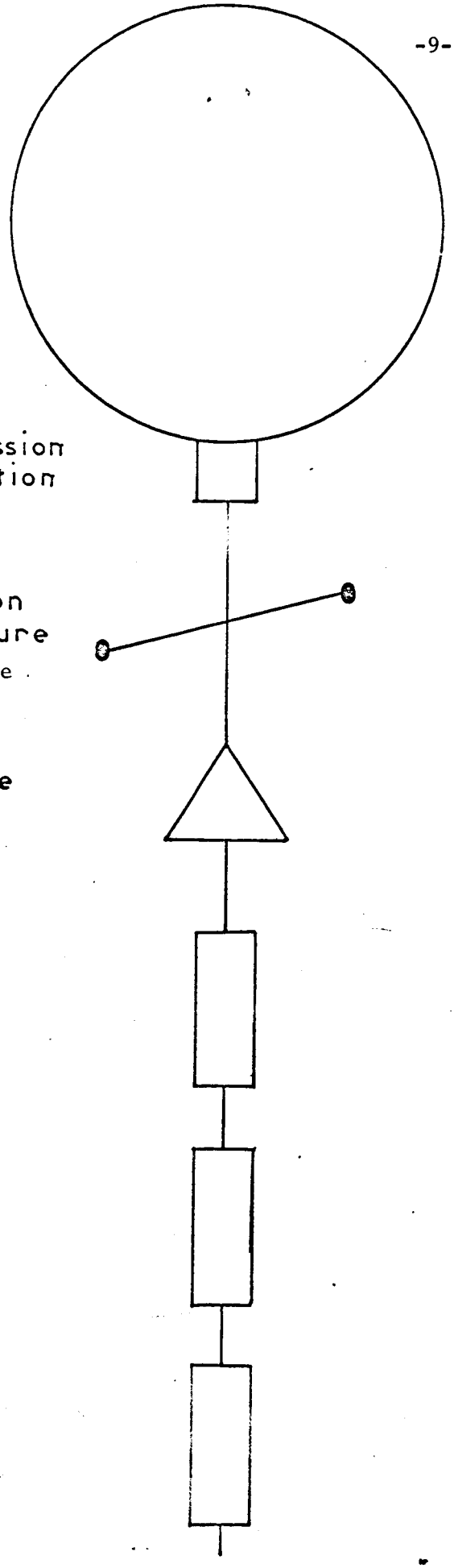
Operation or destruction

Presence of the satellite

No Yes


MINUTERIE ALIMENTATION
Timer power supply
Go
Marche
Arret
Stop
ALIMENTATION
Power supply
Tension batterie
Battery voltage
Capteurs
Captors
RECEPTEUR
Receiver
sortie A
Output
sortie B
Restitution cadence de bits 48 Hz
Restoration cadence of 48 Hz bits
Filtre F0
F0 filter
Filtre F1
F1 filter
Restitution message d'appel
Restoration of call message
DECODEUR
Decoder
COMMUTATEUR
Commutator
DUPLEXEUR
Duplexer
F1
F0
EMETTEUR
Transmitter
Marche Arret émetteur
Go stop transmitter
Modulation
modulation F0 / F1
modulation capteurs
Modulation captors


Appel b1
Call b1
Appel b2
Call b2
Appel b3
Call b3
Appel b4
Call b4
Messages reçus par les ballons (48 Hz)
Messages receives by the balloons
ballon b1
Balloon b1
ordre
order
silence
Silence
début réponse
Beginning of response
porteuse pure
Pure bearing
info distance brouillée
Distance information interferred
info capteurs
Information captors
fin réponse
End of response
début message
Beginning of message
tests
Tests
adresse : non
Address: no
ballon b2
Balloon b2
adresse : oui
Address: yes
destruction
Destruction
info distance
Distance information
ballon b3
Balloon b3
ballon b4
Balloon b4
Diagram of times
DIAGRAMME DES TEMPS



Excess pressure captor

capteur de surpression
système de destruction

Destruction system

Captors
capteurs

pressure
pression

température

temperature

générateur solaire

Solar generator

batterie

Battery

électronique

Electronic

antenne

Antenna

IV - RECEPTION AND TREATMENT ON BOARD THE SATELLITE

IV-1 RECEPTION

The satellite's UHF receiver should be capable of acquiring very rapidly the signal transmitted by the balloon while having a minimum interference after acquisition.

The acquisition time is fixed at about 100 ms (transmission of the pure bearing by the balloon).

Uncertainty on the frequency of the signal received, due to the Doppler effect, is about 40 kHz. These two values impose a sweeping speed of 400 kHz/s of the loop.

The precision of the Doppler measure imposes for the interference band of the receiver, a limit of about 200 Hz.

Incompatibility between this sweeping speed and this 200 Hz band involves the realization of a commutable band system.

The acquisition band has a value of 3,000 Hz, the commutation on the 200 Hz band is accomplished automatically with the help of an intermediary band.

When this commutation is accomplished, the receiver delivers three informations, issued from an amplitude detector, from a phase detector and from the loop oscillator.

IV-2 DOPPLER MEASURE

The frequency signal F issued from the phase loop is joined to the variation due to the Doppler effect by the relation $F = FO + FD$.

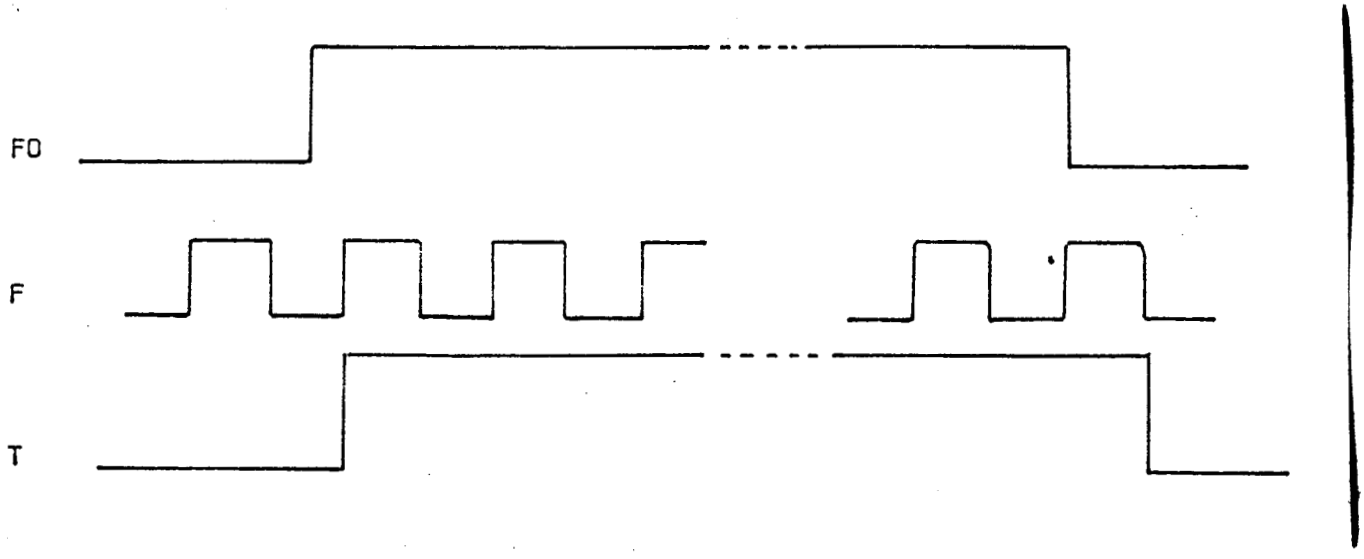
FO is a non fixed frequency

FD is the variation due to the Doppler effect.

The principle of the measure permitting finding F again, whence FD, is realized in the following way:

A battlement T, of duration T elaborated beginning with a fixed and known signal To. This battlement begins at the first passage at 0 of the signal F after the beginning of To and ends at the first passage at 0 of F after the end of To.

Let N be the number of passages at zero, one has: $F = \frac{N}{T}$



One can write: $N = N1 + \Delta N1$

$$T = T1 + \Delta T1$$

N1 and T1 are known constants.

Δ N1 and Δ T1 are measured by counting methods. The measure of ΔN1 necessitates a 15 stage counter, that of Δ T1 a 7 stage counter.

IV-3 DISTANCE MEASURE

The distance measure system contains three integrater phase meters which accomplish:

- a phase measure on the signal available at the amplitude output of the receiver (48 Hz);

- a phase measure on the video signal constituting the fixed "0" (2304 Hz);

- a phase measure on the video signal constituting the fixed "1" (2 688 Hz).

These last two signals are available at the output phase of the receiver.

On account of the satellite/balloon/satellite propagation time (contained between about 5 and 25 ms), the measure is accomplished on a duration of 4 bits. Each phase meter furnishes two X and Y informations giving respectively the co-sign and the sign of defacing. A commutator multiplexes these fixed data in time, and analogical/digital converter transforms them to 6 words of 8 bits.

IV-4 DECOMMUTATION OF THE BALLOON TELEMEASURE

The video signal available at the output phase of the receiver contains in addition to 6 "0" and 6 "1", four frequencies corresponding to the measured parameters on board the balloon.

A loop controlled in phase, swept in frequencies in order to minimize hook-up time, locks itself successively on these four frequencies.

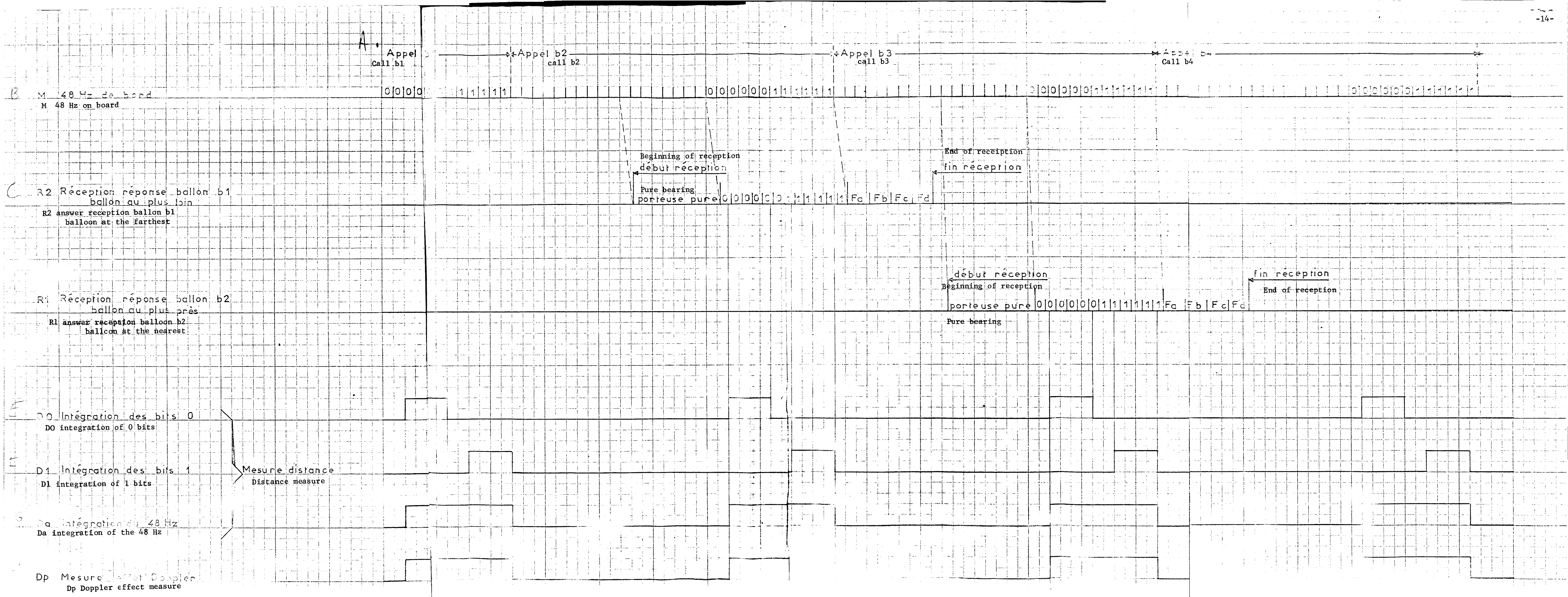
By four successive countings of the loop frequency, one finds again the frequency of the four signals.

The results are presented in the form of 4 words of 7 bits.

The diagram of the system times is represented on page 14.

The signal M is the modulation signal of the satellite containing the call message. The signals R1 and R2 correspond to the reception

on board the satellite of the answer messages of two balloons, R1 at the nearest (satellite vertical), R2 at the farthest (range limit). D0, D1 and Da represent respectively the phase measure time on the "0" bits, the "1" bits and the 48 Hz. Dp represents the time of the Doppler measure.


Appel
Call b1
Appel b2
call b2
Appel b3
call b3
Appel b4
Call b4
M 48 Hz de bord
M 48 Hz on board
0 0 0 0 1 1 1 1 1 0 0 0 0 0 0 1 1 1 1 1 1
Beginning of reception
début réception
End of reciption
fin réception
R2 Réception réponse ballon b1
ballon au plus loin
R2 answer reception ballon b1
balloon at the farthest
Pure bearing
porteuse pure
0 0 0 0 0 1 1 1 1 1 1 Fa Fb Fc Fd
début réception
Beginning of reception
fin réception
End of reception
R1 Réception réponse ballon b2
ballon au plus près
R1 answer reception balloon b2
ballcon at the nearest
porteuse pure
0 0 0 0 0 0 1 1 1 1 1 1 Fa Fb Fc Fd
Pure bearing
D0 Intégration des bits 0
D0 integration of 0 bits
D1 Intégration des bits 1
D1 integration of 1 bits
Mesure distance
Distance measure
Da Intégration du 48 Hz
Da integration of the 48 Hz
Dp Mesure effet Doppler
Dp Doppler effect measure

IV-5 SCIENTIFIC CODER - MEMORANDUM

This coder assures commutation in time of the different informations collected on board the satellite and organizes them in a telemeasure format before transcribing them in the memorandum.

The memorandum thus stores this data, and, on order, sends its content (in biphase code) to the transmitter.

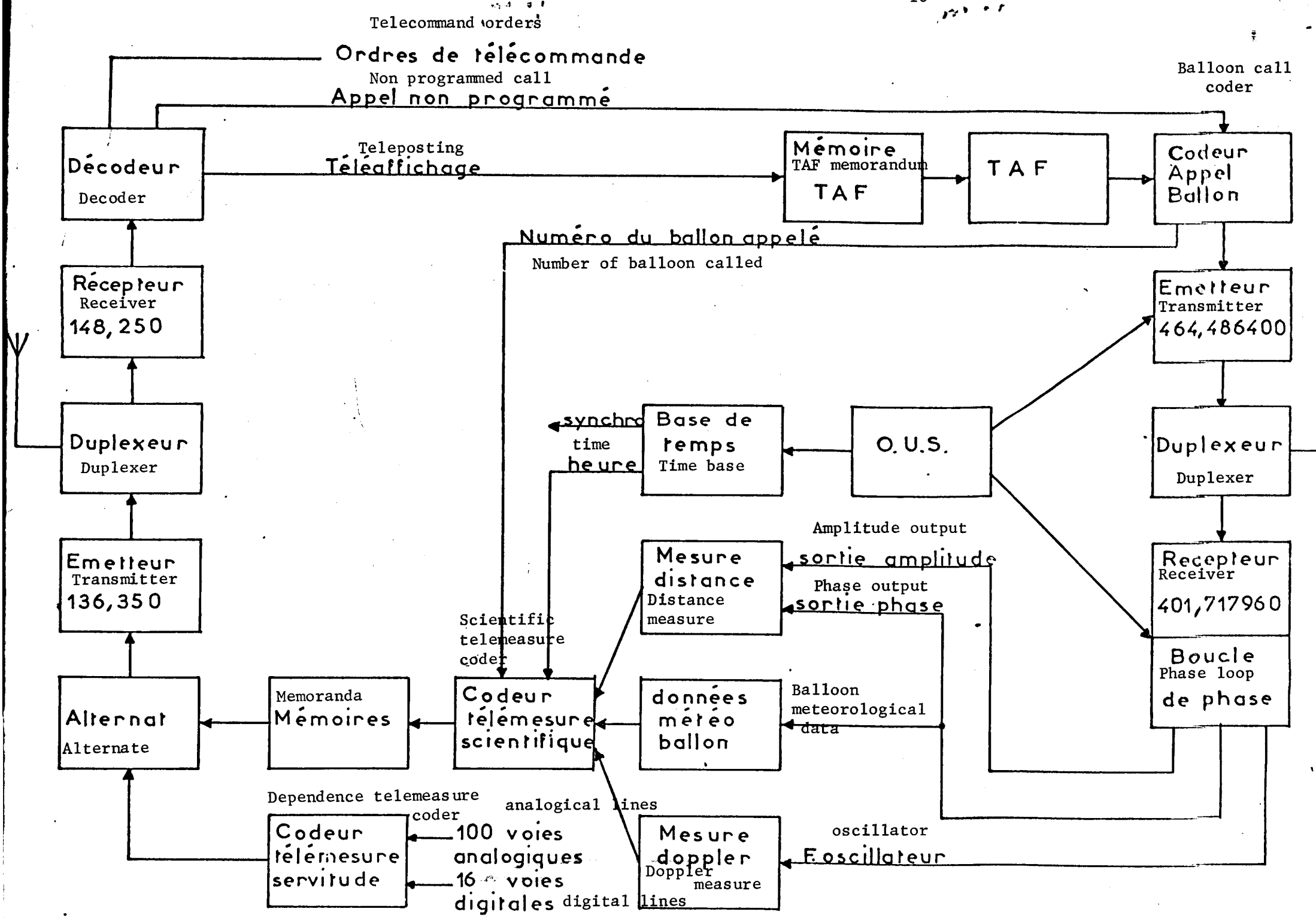
The memorandum is composed of two identical elements M1 and M2, the choice of the elements utilized is fixed by telecommand:

M1 alone - M2 alone - M1 + M2

The capacity of each element is 65 536 bits permitting storing the results of 496 interrogations. The transcribing of the information is produced as soon as it is available. When the memorandum is saturated, the transcription continues, the oldest data is erased.

The reading order automatically involves the transmission, during about 500 ms, of a series of "1" bits. Reading involves the erasing of the data in proportion as it is transmitted. At the time of reading, the memorandum is entirely explored. Other operational characteristics will be defined later.

A synoptic schema of the satellite is presented on page 16.


Telecommand orders
Ordres de télécommande
Non programmed call
Appel non programmé
Balloon call coder
Décodeur
Decoder
Teleposting
Téléaffichage
Mémoire
TAF memorandum
TAF
T A F
Codeur Appel Ballon
Numéro du ballon appelé
Number of balloon called
Récepteur
Receiver
148,250
Emetteur
Transmitter
464,486400
synchro time heure
Base de temps
Time base
O.U.S.
Duplexeur
Duplexer
Duplexeur
Duplexer
Amplitude output
sortie amplitude
Mesure distance
Distance measure
Phase output
sortie phase
Emetteur
Transmitter
136,350
Recepteur
Receiver
401,717960
Scientific telemeasure coder
Boucle
Phase loop
de phase
Alternat
Alternate
Memoranda
Mémoires
Codeur télémesure scientifique
données météo ballon
Balloon meteorological data
Dependence telemeasure coder
analogical lines
Codeur télémesure servitude
100 voies analogiques
16 voies digitales
digital lines
Mesure doppler
Doppler measure
oscillator
Eoscillateur